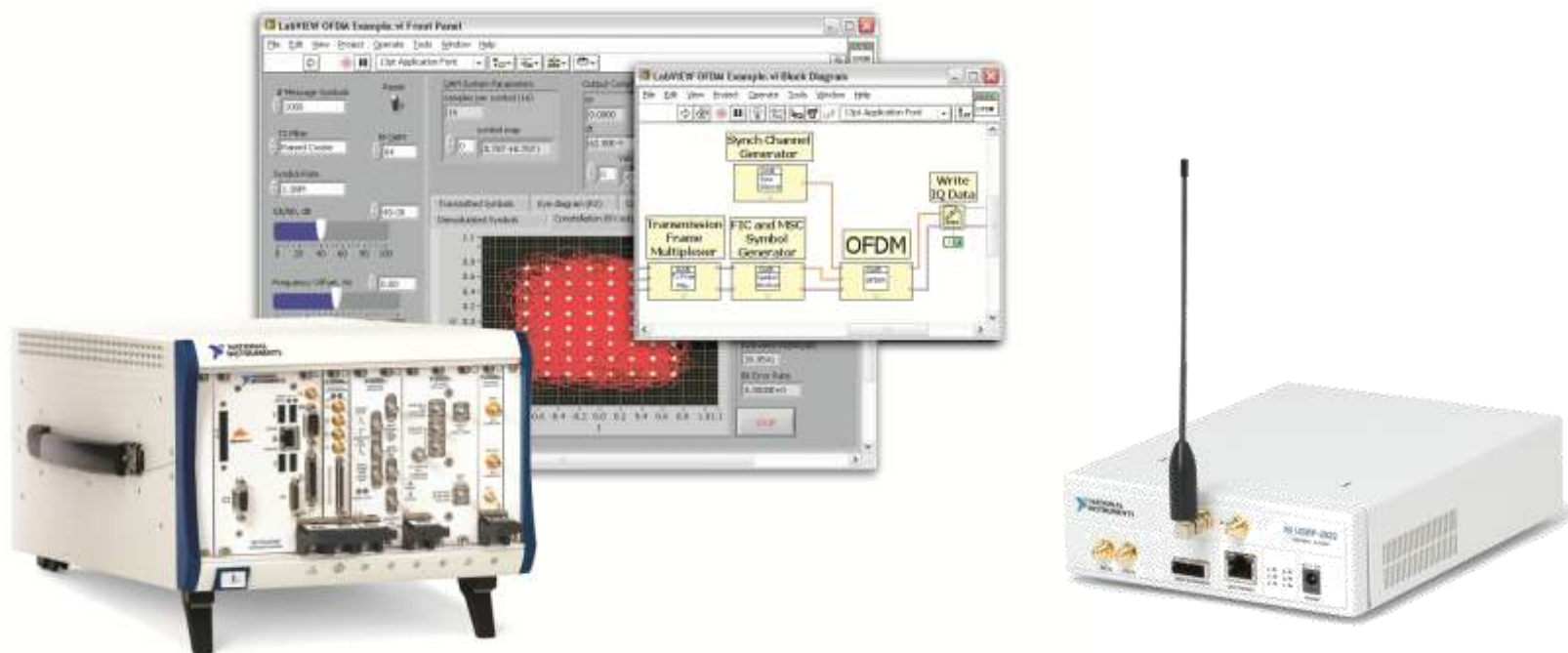




Academic Platforms for RF and Communications



Alex Floor
Academic Field Sales Engineer

NI's Investment in RF & Microwave Test

Research and Development (R&D):

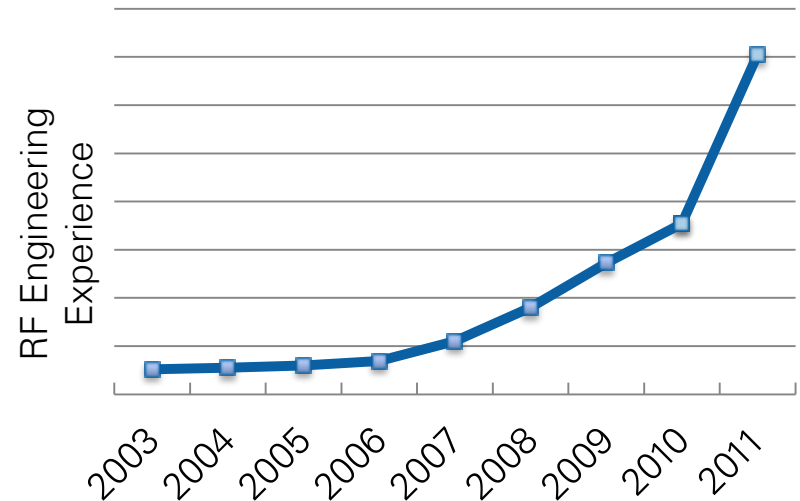
- More than 15 times the R&D investment in RF & Microwave since 2003
- RF & Microwave R&D in 6 global locations
- AWR, Phase Matrix, Signalion and Ettus Research

Support and Services:

- Global Application and Systems Support
- Extensive System Deployment Services

Products:

- Pioneered RF in PXI form factor
- Over 60 RF & Microwave Products

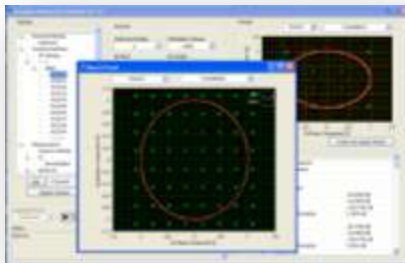


NI RF Platform

Optimized APIs



Soft Front Panels

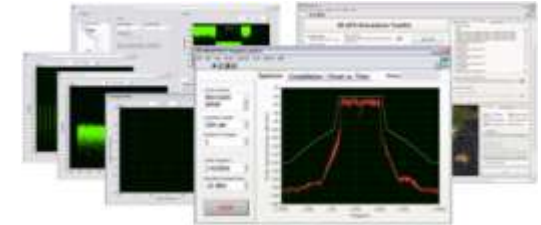


Highly Modular Hardware & Software

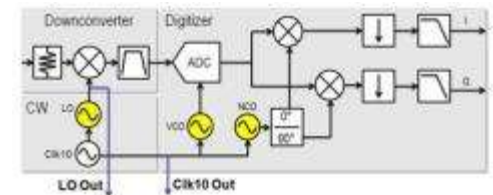


Cellular, Wireless, and GPS Test Toolkits

(802.11 a/b/g/n , GSM/EDGE,
WCDMA, LTE, WiMAX, GPS, etc.)



Reference Architectures



Multicore
Processing



RF Signal
Generators &
Analyzers



FPGA I/O and
Coprocessing



RF Vector
Network
Analyzer



Switching,
Amplifiers,
Attenuators



Power
Meters

NI PXIe-5665: 14 GHz Spectrum Analyzer

- **Specifications**

- Freq Range: 20 Hz to 3.6 / 14 GHz
- Analysis BW: 25/50 MHz with DDC
- Noise Floor : < -154 dBm/Hz (< -165 dBm/Hz) @ 1 GHz
- IP3: $> +24$ dBm (700 MHz to 3.6 GHz)
- Phase Noise: -129 dBc/Hz (800 MHz at 10 kHz offset)
- Form Factor: PXI Express (x4),
3.6 GHz - 5 slots
14 GHz - 7 slots

- **Features**

- Preselector from 3.6 to 14 GHz
- RF List Mode
- Multichannel receiver architecture
- High-speed data streaming and P2P
- Optional pre-selection filters and IF conditioning optimized for OTA measurements



Fraction of the Size of Traditional Solutions

The World's First Vector Signal Transceiver



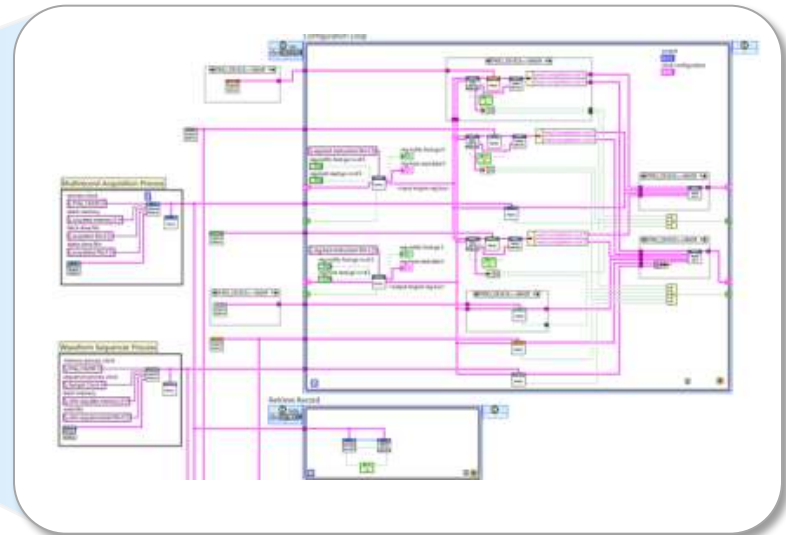
Vector Signal Analyzer + Vector Signal Generator = Vector Signal Transceiver

World's First Software Designed Instrument

Powered by NI LabVIEW



FPGA-based Hardware Architecture

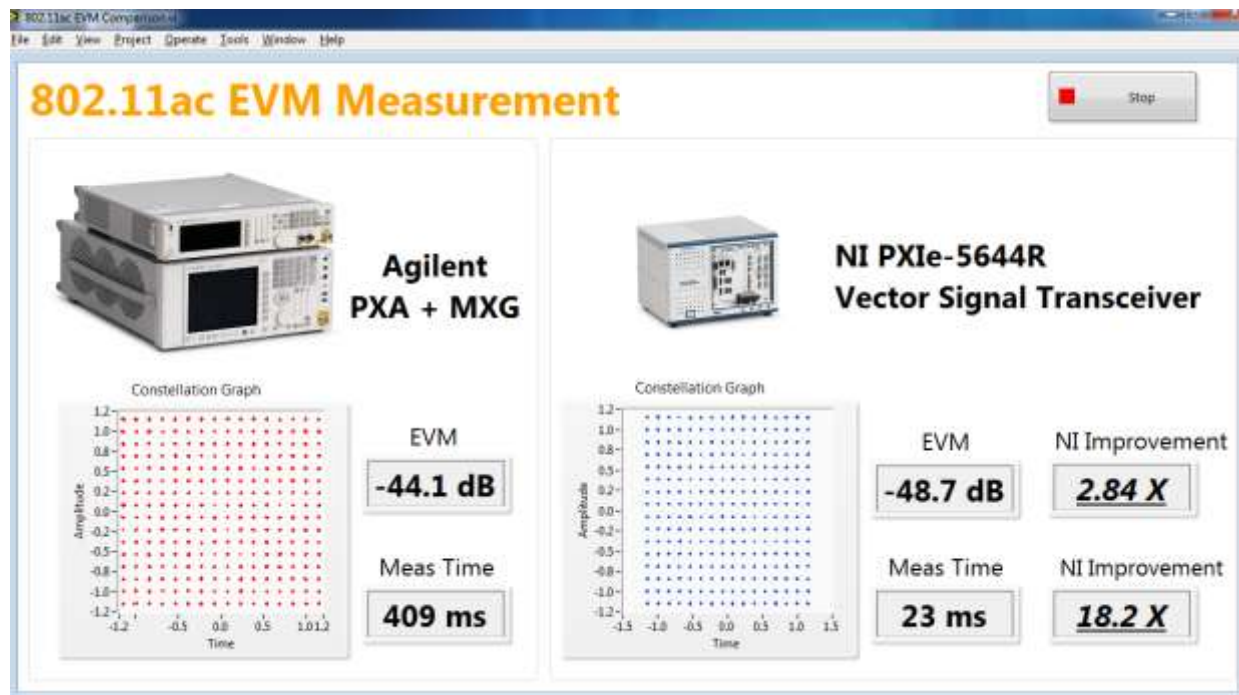


Graphically design your instrument in NI LabVIEW FPGA

- Up to 6.0 GHz frequency coverage
- 80 MHz analysis bandwidth
- Integrated RF generation, RF analysis and high-speed digital

Best in Class Measurements: WLAN 802.11ac

- NI 5644R vs Agilent PXA/MXG
- 3-5dB better performance
- 10x faster measurement time



Software-Designed Instrumentation

Frequency Domain Averaging

Power Level Servoing

Protocol Aware ATE

Noise Correction

Channel Emulation

Software Defined Radio

Frequency Triggering

Vector Signal Analyzer

Test Sequencing

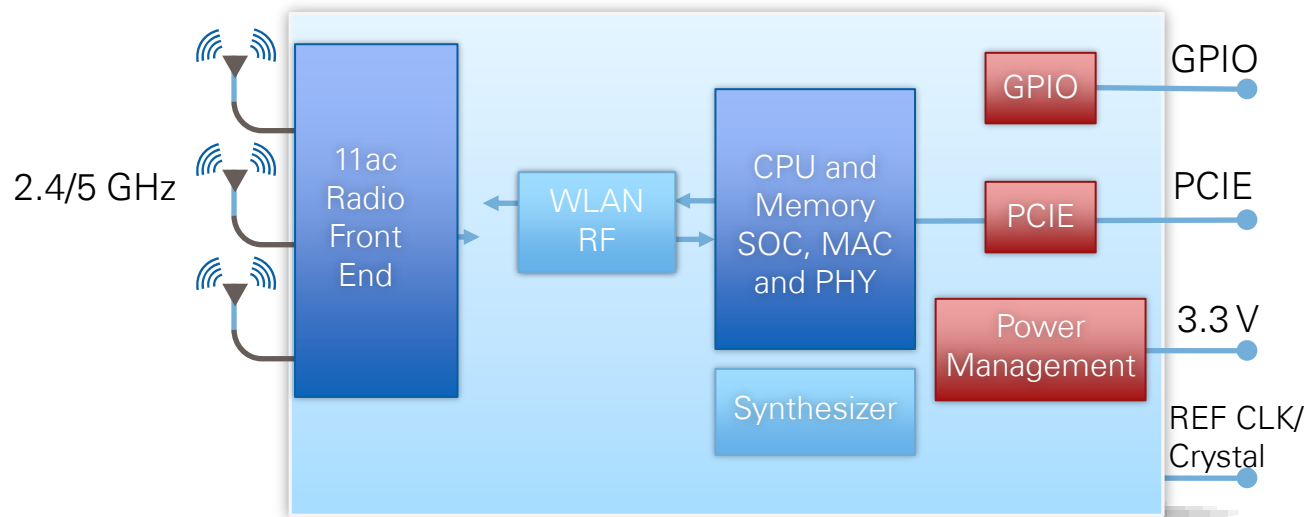
Vector Signal Generator

DUT Control





- The networking and connectivity subsidiary of Qualcomm, Inc.
- Leading provider of wired and wireless technologies
- Serving mobile, computing, consumer electronics and networking channels



802.11ac Device Block Diagram

RF Standards—Increasing Complexity

802.11a + b + g

- Over 30 Channels
- 20 Modulations
- 1 Filter Width
- 1 Spatial Stream

100+ Combinations

+ 802.11n

- Over 50 Channels
- 28 Modulations
- 2 Filter Widths
- 4 Spatial Streams

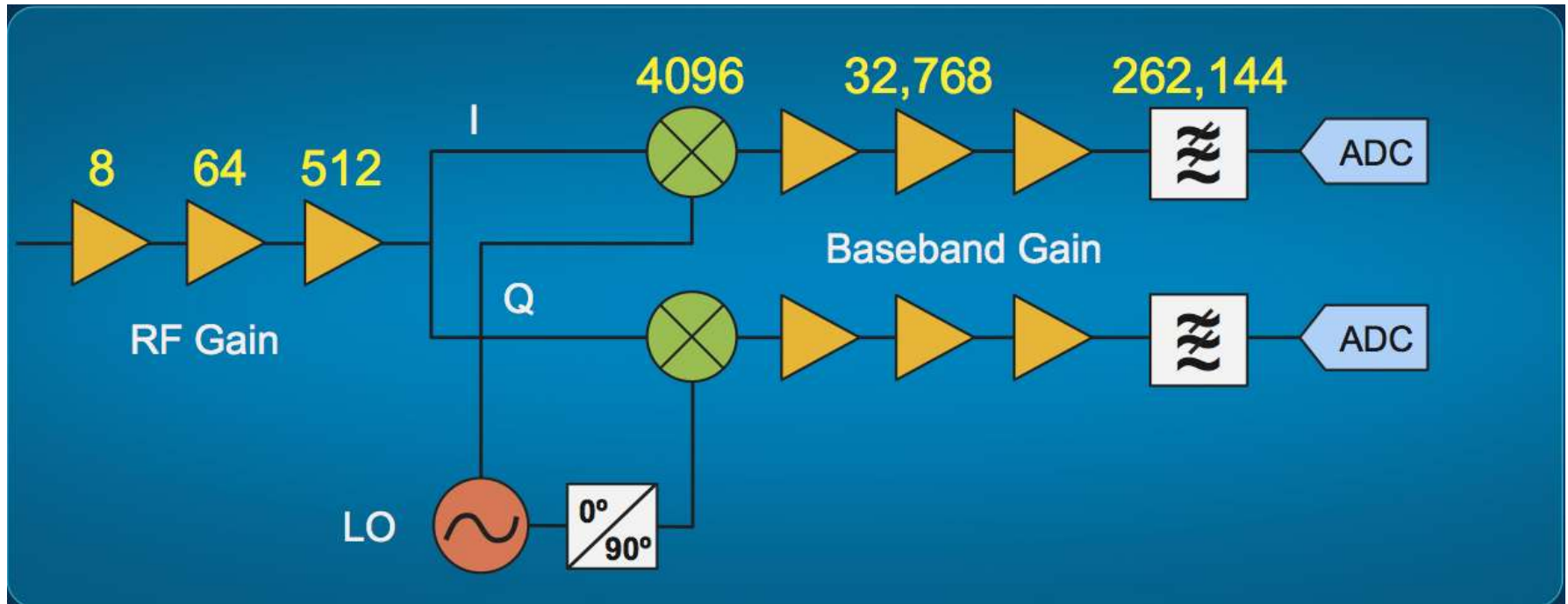
1,000+ Combinations

+ 802.11ac

- Over 100 Channels
- 38 Modulations
- 4 Filter Widths
- 8 Spatial Streams

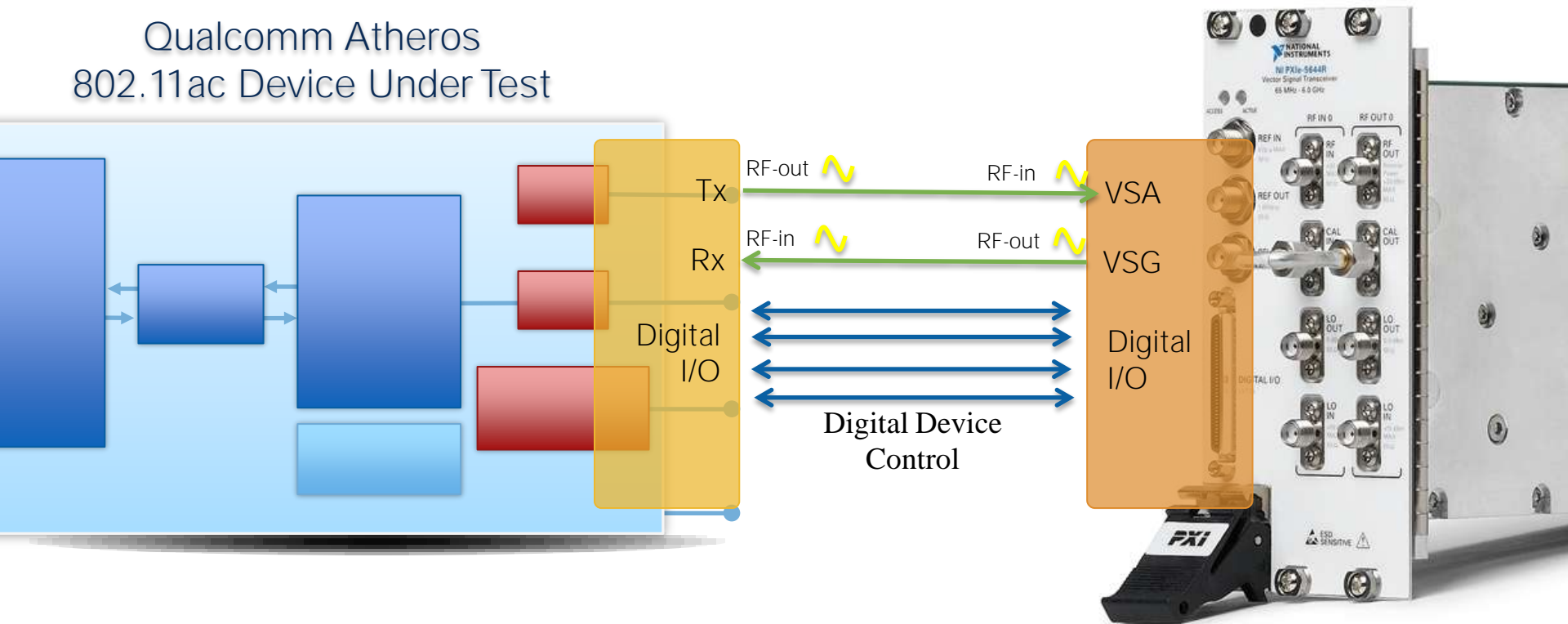
10,000+ Combinations

Example WLAN Receive Chain

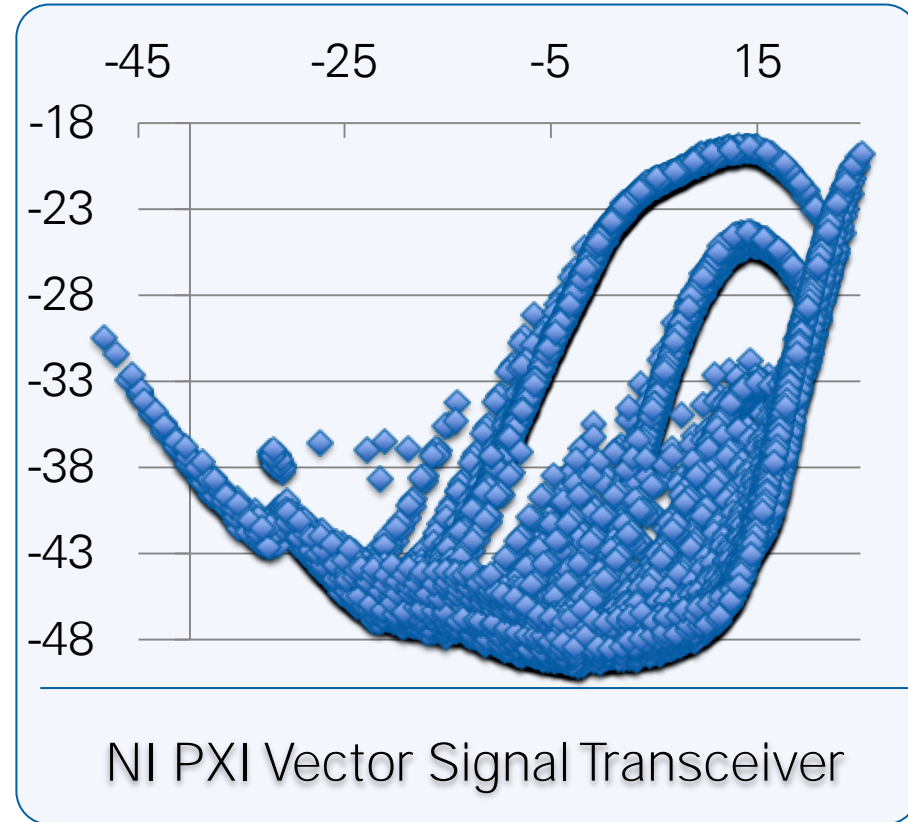
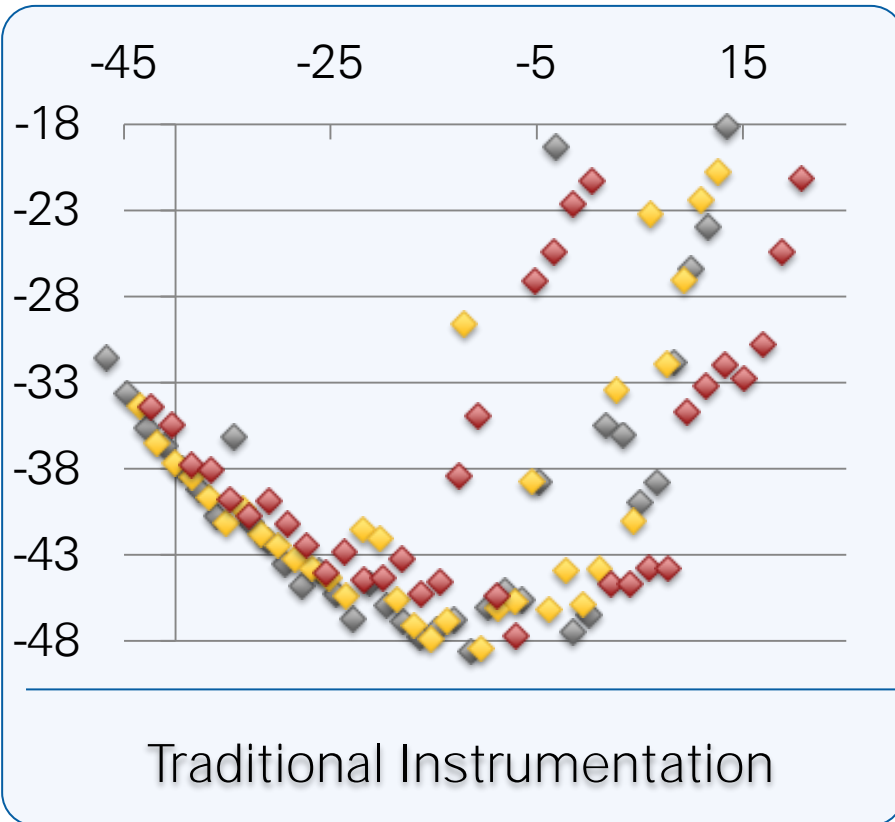


Vector Signal Transceiver/Device Under Test Integration

Qualcomm Atheros
802.11ac Device Under Test



EVM (dB) Versus Average Output Power Chain



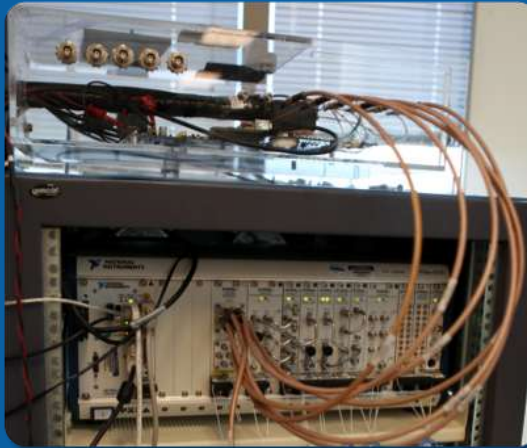
Qualcomm Results

802.11a + b + g



Early 2000s—Traditional Rack and Stack

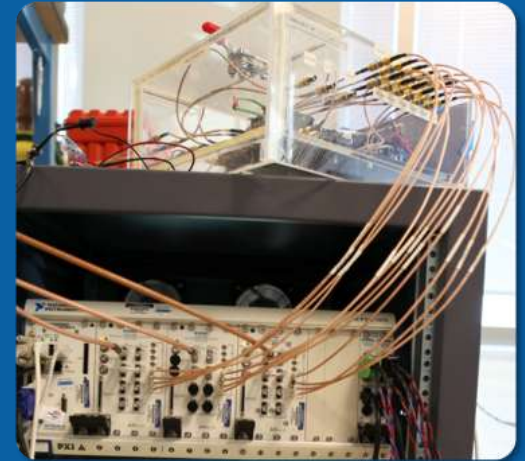
+ 802.11n



2007—NI PXI RF Instrumentation

10X Faster Than Traditional

+ 802.11ac



2012—NI PXI Vector Signal Transceiver

200X Faster Than Traditional

NI FlexRIO: IP to the Pin Technology

Reconfigurable, user-defined IP at the I/O pins



FlexRIO Adapter Module

- Interchangeable I/O
- AI, AO, DIO, Serial
- Customizable by users
- Module Development Kit

FlexRIO FPGA Module

- Up to 132 channels
- Up to 1 Gb/s per pair
- Up to 512 MB of DDR2 DRAM

Downloadable FPGA IP :

- Control logic
- Data transforms
- Waveform creation
- Digital protocols
- Encryption
- Math algorithms
- RF signal processing



Browse, Download, and Share LabVIEW FPGA IP

<http://www.ni.com/flexrio/>

<http://zone.ni.com/devzone/cda/tut/p/id/4799>

NI 5791 RF Transceiver Adapter Module

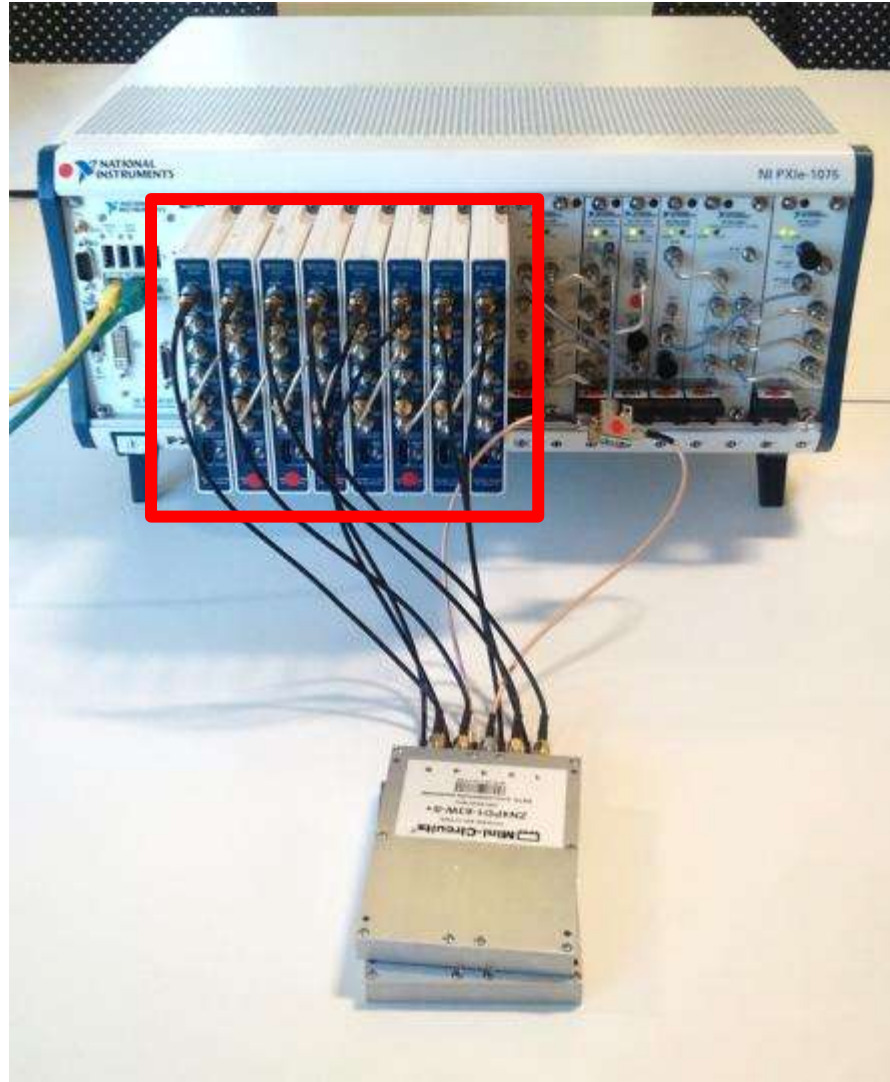


- 200 MHz – 4.4 GHz RF Transceiver
- 100 MHz bandwidth
- Direct up and downconversion
- 130 MS/s, 14-bit input, 16-bit output I/Q interface on NI FlexRIO FPGA Module
- 12 DIO for digital control

A possible 8x8 MIMO Testbed



A new 8x8 MIMO Solution



NI and TU Dresden Collaborate on 5G Wireless



5G Lab and Test Bed

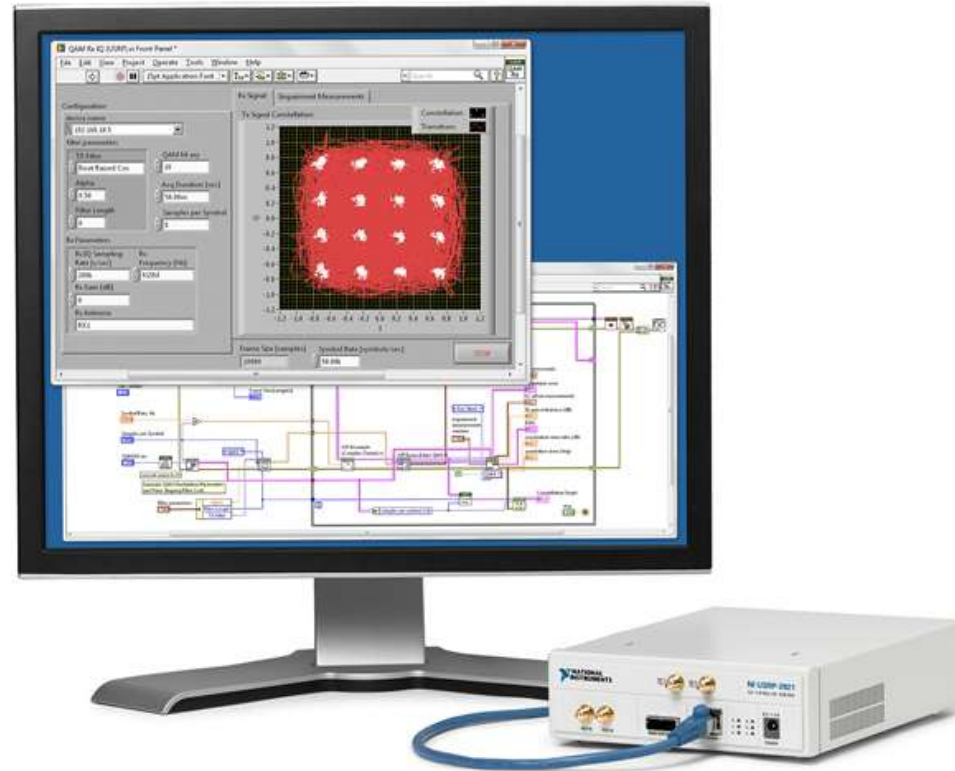
5G PHY exploration and prototyping

Using LabVIEW system design software



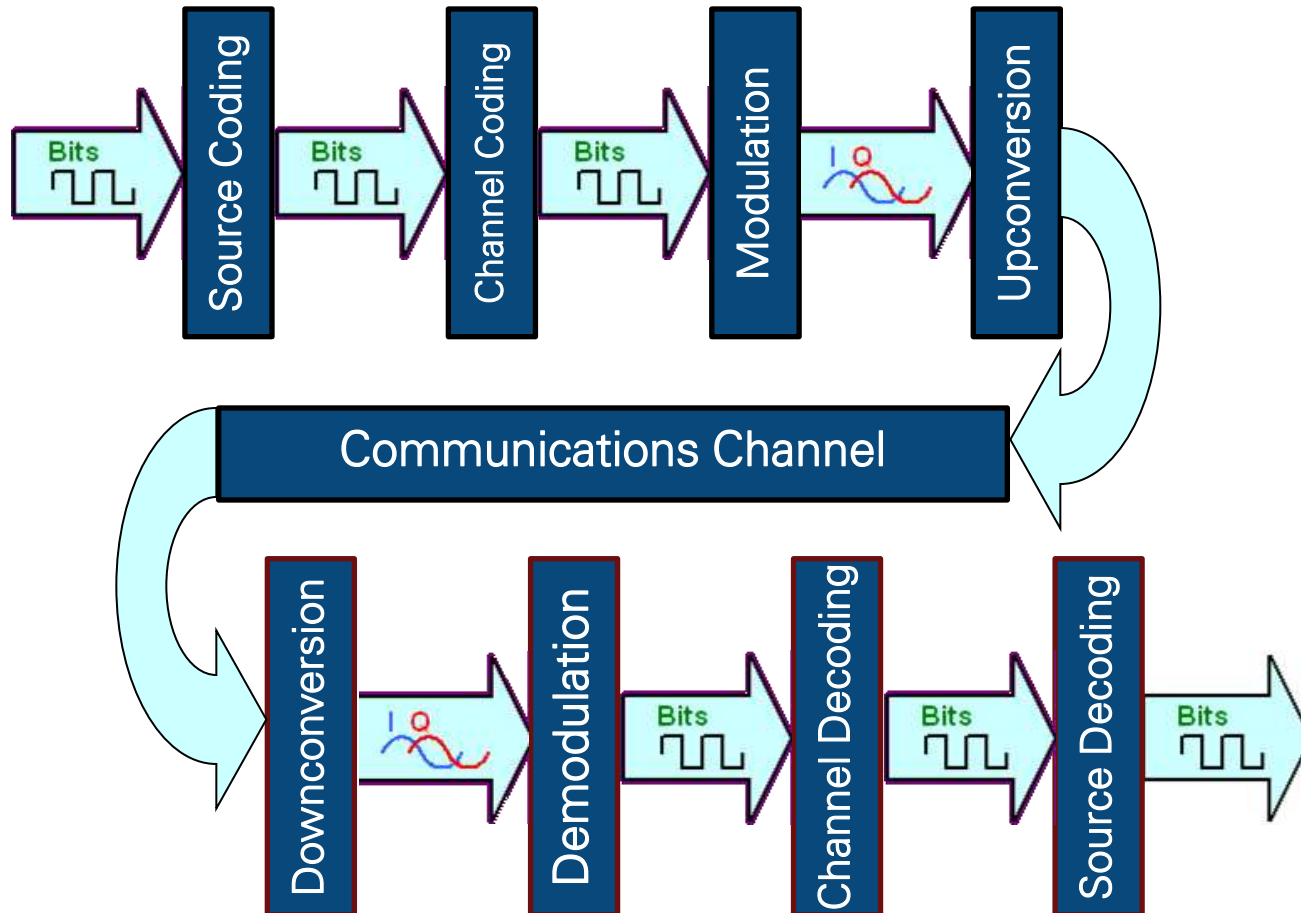
Dr. Gerhard Fettweis





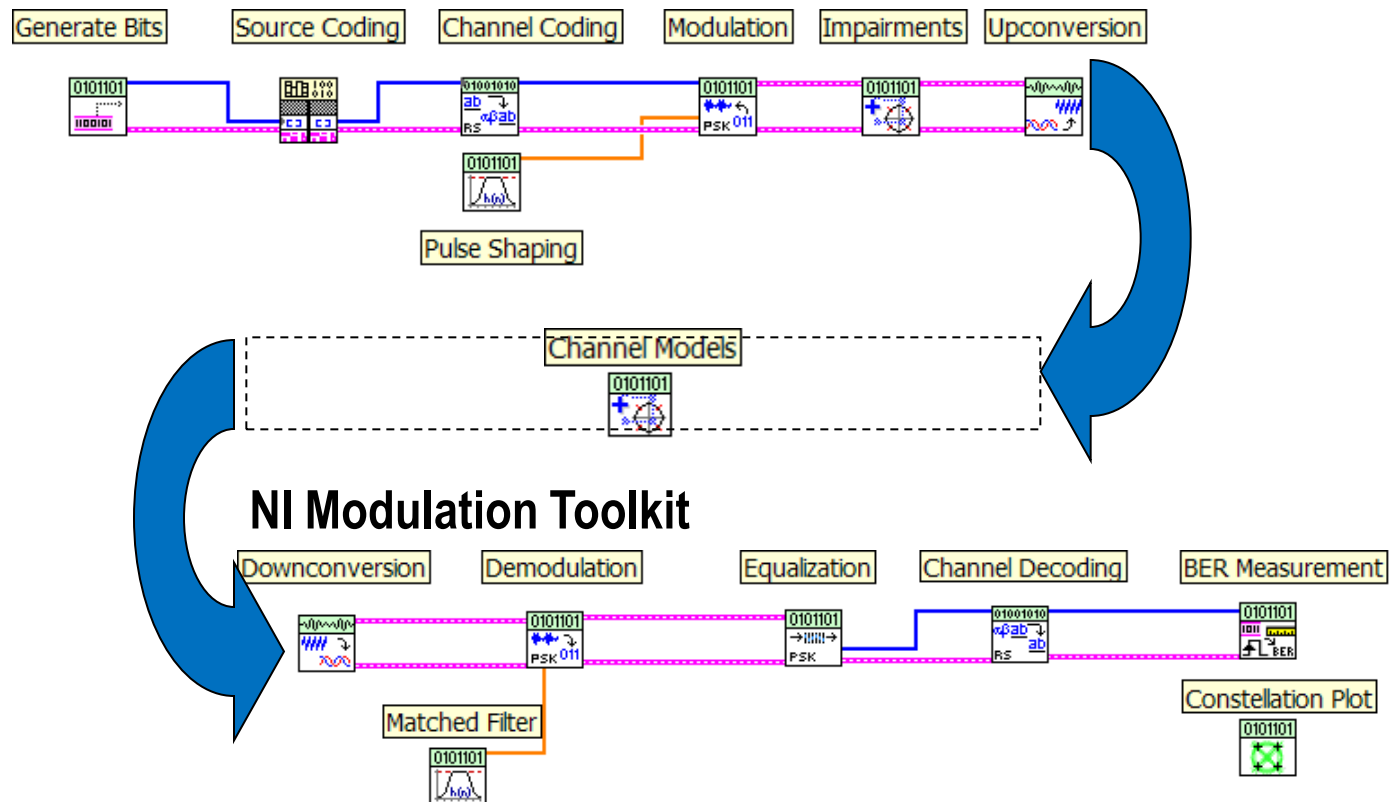
NI USRP | Do Engineering: In Communications Design

Digital Communication System



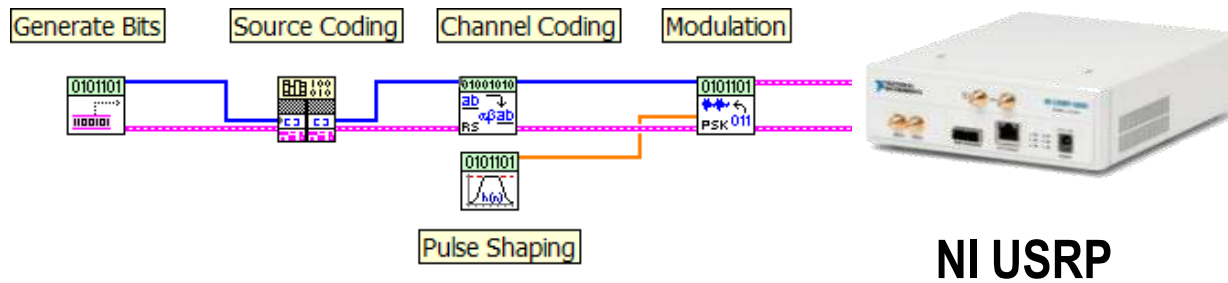
Digital Communication System

NI Modulation Toolkit

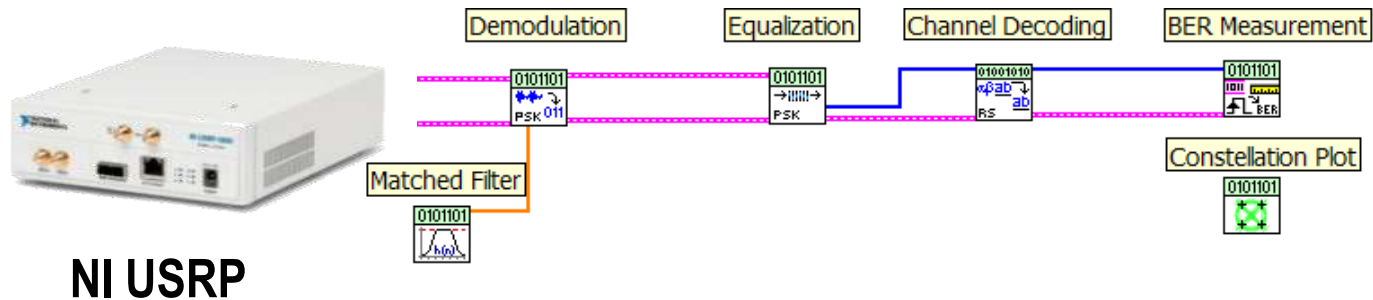


Digital Communication System

NI Modulation Toolkit



NI Modulation Toolkit



NI USRP

Tunable RF Transceiver Front Ends

- Frequency Range
50 MHz – 2.2 GHz (NI-2920)
2.4 GHz & 5.5 GHz (NI-2921)
400 MHz – 4.4 GHz (NI-2922)

Signal Processing and Synthesis

- NI LabVIEW to develop and explore algorithms
- NI Modulation Toolkit and LabVIEW add-ons to simulate or process live signals



Applications

- FM Radio
- TV
- GPS
- GSM
- ZigBee
- Safety Radio
- OFDM
- Passive Radar
- Dynamic Spectrum Access

1 Gigabit Ethernet Connectivity

- Plug-and-play capability
- Up to 25 MS/s baseband IQ streaming

Digital Communications Bundle

Bundle Contents

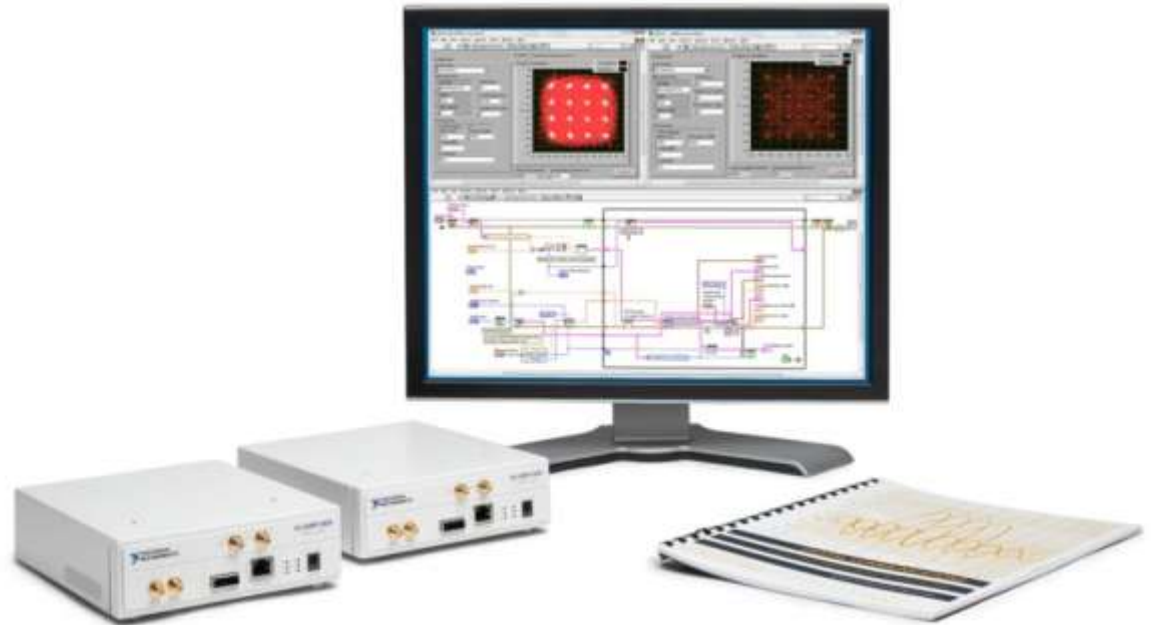
- Two NI USRP-2920 + Toolkits
- MIMO Cable
- Digital Comm Lab Manual

Key Benefits

- Affordable
- Accessible
- NI Supported
- TX & RX Real RF Signals
- Scales to Research

Target Courses

- Communication Systems
- Digital & Wireless Communications
- Software Defined Radio (SDR)



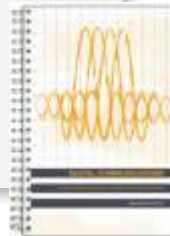
Lab Ready | Packet Radio & OFDM

Digital Communications Labs

by Dr. Robert Heath, UT Austin

- 1 QPSK AWGN Simulator
- 2.1 Modulation /Demodulation
- 2.2 Pulse Shaping
- 3 Energy Detection
- 4 Equalization
- 5 Frame Detection
- 6 Intro to OFDM
- 7 Frequency Correction & Sync
- 8 OFDM Channel Coding

(Ships in Bundle)



Communications Systems Labs

by Dr. Sachin Katti, Stanford

- 1 Source Coding
- 2 Packet Communication, Sync, and Channel Correction
- 3 Modulation
- 4 Demodulation
- 5 Design Challenge:
Packet based Transceiver

(FREE: ni.com/courseware)

NI USRP at Stanford University

Student Course Feedback:

“

Awesome class! I really enjoyed the lectures, where I learned a lot, and the labs were really cool because we got to use the hardware.
... I am glad that I took this class!

”

Source: Stanford EE 49: Teaching Evaluations (Spring Quarter 2011)

NI USRP at Stanford University



“

...with the NI USRP, we're able to provide exposure in introductory courses for the first time.

”

“

Students rated the class **4.94/5.0**, likely making it one of the **highest ratings among all classes** in the School of Engineering at Stanford.

”



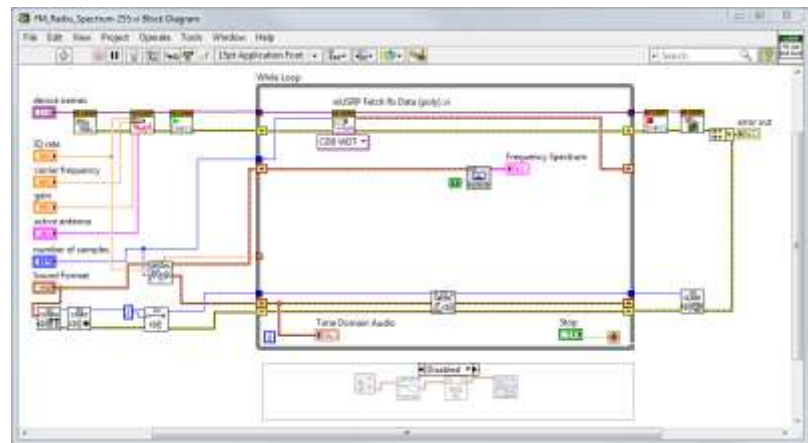
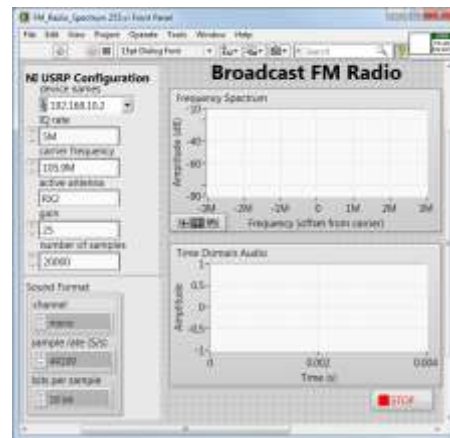
Dr. Sachin Katti

[Electrical & Computer Engineering]

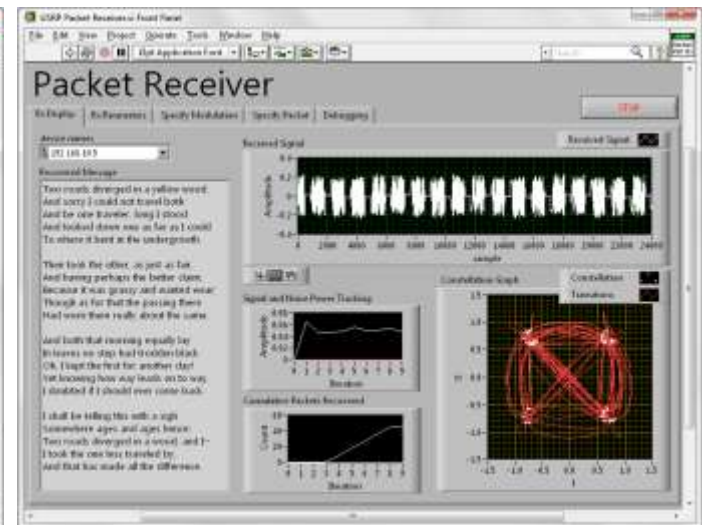
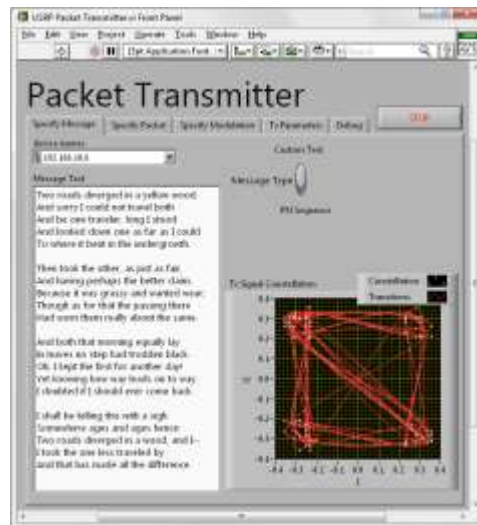
Demo

1. Show the simplicity of programming the USRP
 - Open the palette and do a simple spectrum scan

2. Simple app
 - FM radio

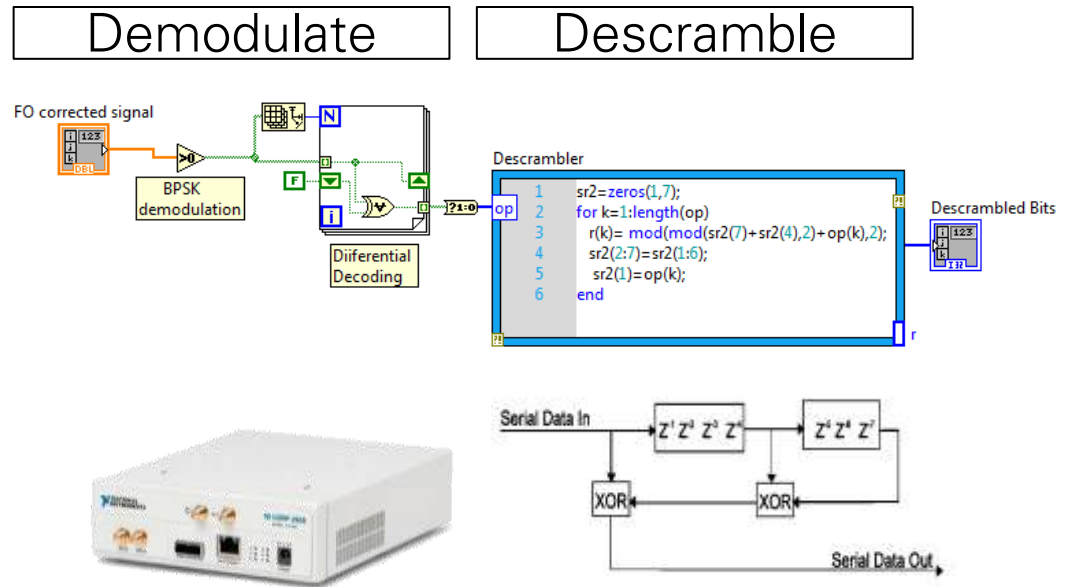


3. Adv app
 - Packet



NI USRP Research Case Study: Physical Layer Prototyping

- Continuously monitoring multiple wifi channels
- Demodulation and descrambling of 802.11b beacon signals
- Identification of hotspots, tracking relative power levels



802.11b SSID Decoding

Carrier
Detection

Frequency
Offset
Estimation &
Correction

Demodulation
&
Descrambling

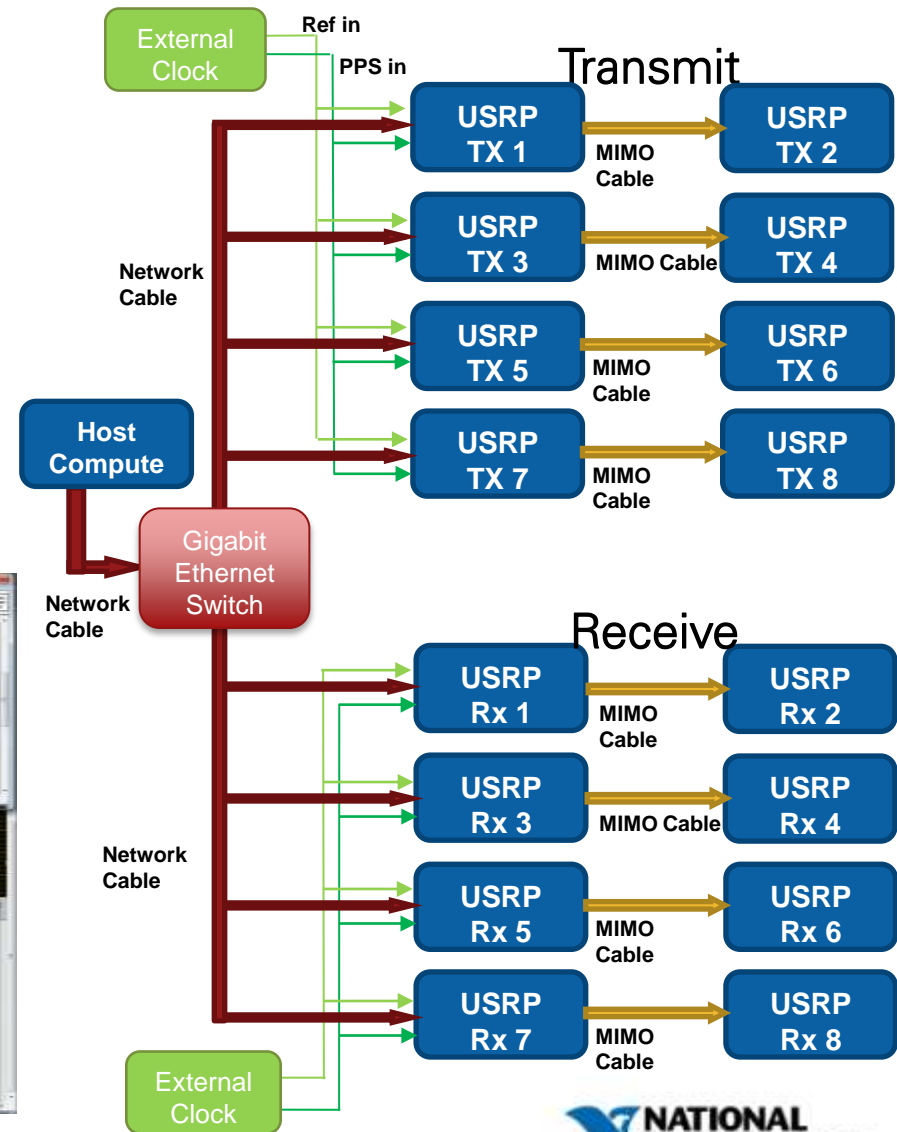
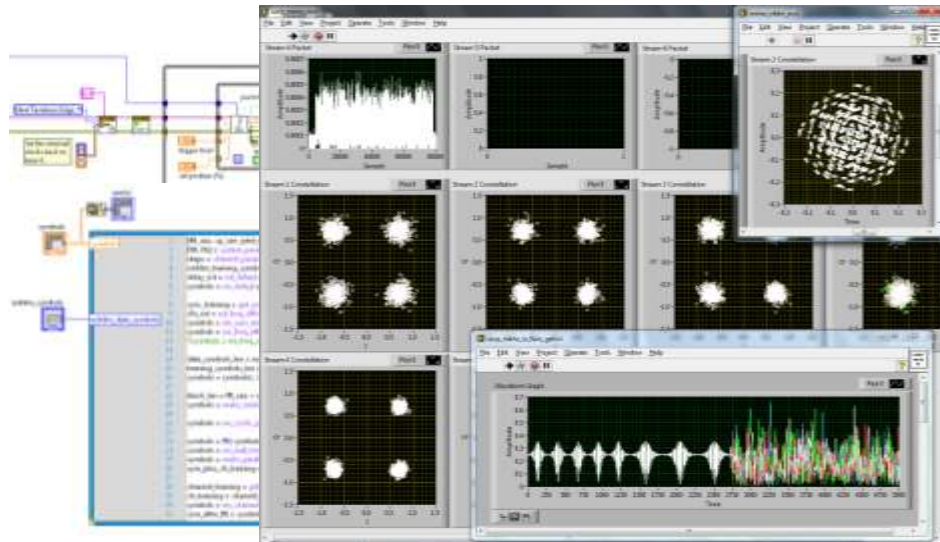
Interpret the
frame for
SSID

NI USRP Research Case Study: NI USRP 8x8 MIMO Testbed



Dr. Robert Heath
Director WNCG
University of Texas at Austin

- Adaptable from 2x2 to 8x8
- Algorithm design in MathScript RT
- 128 subcarrier OFDM, 4 QAM, spatial diversity
- Independently clocked, phase coherent Tx & Rx



Summary

- LabVIEW offers a graphical approach, shortening the design process, and tight hardware/software integration that allows for seamless transition from design to test
- NI provides a full spectrum of RF / Communications solutions: RF Test, Research and Education
- LabVIEW and NI USRP is an accessible, easy-to-use software defined radio platform

